

the sand-pendulum, being careful that when the board is slid under the stationary pendulum the point of the funnel goes precisely over the centre line LM (Fig. 9) of the curve.

Now draw the point of the funnel aside to a distance from the line LM equal to one-half of AB, or, what is the same, from 5 to 5' of Fig. 9. Pour sand in the funnel, and let the bob go. At the moment the point of the funnel is over L, slide the board along so that when the point of the funnel comes the third time to the line LM, it is at the end M of this line. This you may not succeed in doing at first, but after several trials you will succeed, and then you will have an answer from the pendulum as to the kind of motion it has, for you will see the sand from the swinging pendulum strewn precisely over the curve you placed under it. Thus you have conclusively proved that the apparent motion of the conical pendulum, along the line AB, is exactly like the swinging motion of an ordinary pendulum.

As it is difficult to start the board with a uniform motion at the very moment the pendulum is over the line LM, it may be as well to tack a piece of paper on the board with no curve drawn on it, and then practise till you succeed in sliding the board under the pendulum, through the distance LM, in exactly the time that it takes the pendulum to make two swings. Now, if you have been careful to have had the swing of your pendulum just equal to AB, or from 5 to 5' on the drawing of the curve, you will have made a curve in sand which is precisely like the curve you have drawn; for, if you trace the sand-curve on the paper by carefully drawing through it the sharp point of a pencil, and then place this trace against a window-pane with the drawing of the curve, Fig. 6, directly over it, you will see that one curve lies directly over the other throughout all their lengths.

This curve, which we have made from the circle in Fig. 6, and have traced in sand by the pendulum, is called the *curve of sines*, or the *sinusoid*. It is so called because it is formed by stretching the circumference of a circle out into a line and then dividing this line, LM of Fig. 6, into any number of equal parts. From the points of these divisions 1, 2, 3, 4, 5, &c., of LM, we erect perpendiculars 2 2', 3 3', 4 4', 5 5', &c., equal to the lines a 2, b 3, c 4, d 5, &c., in the circle. These lines in the circle are called *sines*, so when we join the ends of these lines, erected to the straightened circumference by a curve, we form the curve of sines, or the sinusoid.

The sinusoid occurs often during the study of natural philosophy. We may meet with it again in our book on the nature of light, and it certainly will occur in our book on heat.

(To be continued.)

NOTES

UP to the present time the ignorance of those who did not know that the Archbishop of Canterbury was a degree-giving body was pardonable. It is so no longer. A serious alteration in the arrangements of these diplomas is now announced. Archbishop Tait, while he intends to dispense doctorates as before at his will and pleasure, has determined that his degree of M.A. is from December next to be a matter of examination. The standard is to be that of "honour examinations in the Universities." There is to be due choice of subjects, among which, however, Greek and Latin are not to be compulsory, though English literature is. To qualify for examination, formal testimonials required for University matriculation, with the addition of a certificate from the Bishop of the diocese whence the candidates come, are required. As the *Daily News* puts it, "the Archbishop has evidently determined to make himself into a university with all the paraphernalia which the modern conception of such a body requires." Both the London Examining Board (commonly called the London University) and Owens College

are to be congratulated on the publicity now given to this singular system of granting degrees. The London Examining Body is not a teaching body, neither is the Archbishop, but the Archbishop is a university, therefore the London University system is perfect, and all methods of education whatever may be disregarded so that a standard of instruction is reached. Owens College as a teaching centre which has won its way to general esteem and confidence, may now bide its time, for this last grotesque thing calling itself a university will either make the power of granting degrees, and degrees themselves ridiculous, or direct attention to the whole subject.

ALTHOUGH the Paris meeting of the Iron and Steel Institute has not called for any lengthy notice at our hands, there are passages in Dr. Siemens' admirable address to which we cannot too strongly draw attention, and which we are anxious to place on record in our columns. He remarked that "Whilst the English, to realise a novel proposition, make bold attempts, not always carefully matured beforehand, the French systematically study a question in all its aspects, and fortify their views by careful inquiry into the experience obtained elsewhere, before they commence operations which are then carried out with all the economical and other advantages resulting from such an exhaustive preliminary inquiry. If we seek a cause for the remarkable aptitude of adapting means to special ends, to which I have referred, we shall probably find it in the advantages France and other continental countries have enjoyed for at least a generation of a more extended technical education than we could boast of, and of the personal influence which has been exercised by a line of scientific writers and experimentalists, of whom I shall only mention here such honoured names as those of Réaumur, Ebelmen, Rénault, Pouillet, Pécelet, Thomas, and Le Châtelier, as belonging to the past, and of Deville, Grüner, Lan, Laurens, Jordan, Frémy, and Dumas, who are fortunately still among us. It is chiefly to such men as these that France owes her admirable system of education, which enables her to place her metallurgical establishments under the guidance of men who are scientifically qualified for the discharge of their respective duties, and for the attainment of practical results which may well excite our admiration." The organisation of the École Centrale, the creation of M. Dumas, recommends itself, as it may well do, to Dr. Siemens, and he points out that the only establishment in Great Britain comparable with the École Centrale as regards metallurgy is our School of Mines, which, "if it were installed in a capacious building, and had other branches of knowledge added to its curriculum, might easily, under the guidance of such men as Percy, Smyth, Frankland, and Huxley, be developed into an institution which would give rise to beneficial results difficult to over-estimate." Had Dr. Siemens been speaking in England he would doubtless have added that this was the distinct recommendation made by the Duke of Devonshire's Commission after a long inquiry. The Government has not yet acted upon this recommendation, and the result is that students of the School of Mines have to get their mathematics when and how they can; they form no part of the curriculum. Many may think that such schools in France are too heavily weighted with mathematics, but to omit the subject altogether is to court Scylla with a vengeance. Why should not each student of the School of Mines receive, as at the École Centrale, a three years' course of general scientific education, including the higher branches of mathematics, as well as physical science, pure and applied chemistry, geology, mechanics, metallurgy, and mineralogy.

MR. H. FORBES, F.L.S., is about to leave this country to investigate the fauna and flora of Celebes, Borneo, and adjacent islands. He proposes to devote five or six years to the work.

VESEVIUS is now giving some very definite signs of an eruption.

MR. JOHN PENN, F.R.S., the eminent marine engineer, died on Monday last, at Lee, in his seventy-third year. Mr. Penn's various patents for marine engines were considered so good that no fewer than 740 British war vessels were fitted with his machinery. Among them were the *Warrior*, the *Black Prince*, the *Achilles*, the *Hercules*, and the *Sultan*. Messrs. Penn also supplied the engines for nearly all the largest war ships for the Italian, Spanish, Brazilian, German, Danish, and Peruvian Governments, and those for the yachts of the Queen, the Emperor of Russia, the Khedive, the Sultan, and the Emperor of Austria. Mr. Penn was elected a member of the Institution of Civil Engineers in 1828, and a Fellow of the Royal Society in 1859. He was also a past president of the Society of Mechanical Engineers, and had received many marks of distinction from various foreign governments.

MESSRS. BARRAUD AND JERRARD are to be congratulated on the latest issue of their fine plate containing a collection of portraits of Fellows of the Royal Society produced from photographs and printed in "permanent print." Most of the portraits and many of the *poses* are very lifelike, and the introduction of so many portraits into one picture, while retaining a certain artistic effect, has not been accomplished without a considerable overcoming of difficulties. The full-length portraits of the Astronomer-Royal, Sir J. Lubbock, Dr. Richardson, Dr. Siemens, Dr. Lister, Dr. Spottiswoode, and Prof. Martin Duncan, in the fore-front, are all excellent. A convenient key accompanies the plate.

THE Seth Thomas Clock Company have recently introduced a time-keeper with a novel and most useful addition. This consists of a perpetual calendar, the day, date, and month being shown on a second dial. We have personally tested the action of this part and can state that the mechanism takes ordinary leap years perfectly into account. Indeed, the novelty is a marvel of ingenuity. We hope later to be able to give more details.

THE Trustees of the Australian Museum seem not only to have an unhappy knack of getting into hot water, but a strong feeling that it is good to remain in it. Without entering into the quarrel between them and the late curator, any one will regret the course of action thus referred to in the last report "to his Excellency, the Governor-in-Chief":—"The Trustees regret to state that, notwithstanding their strenuous endeavours to bring all disputes with their late Curator to a satisfactory conclusion, and to relieve the institution of the custody of the whole of the property which they could admit to belong to him, that gentleman has thought fit to bring an action to recover certain medals awarded to him as Curator of the Museum in respect of property of the Museum exhibited on various occasions, at the expense of the Museum, and certain specimens and articles of clothing and furniture alleged to have been detained by the Trustees. The Crown Solicitor was authorised by the Minister of Justice and Public Instruction to defend the action, which came on for trial in the Supreme Court on November 6, and resulted in a verdict against the Trustees of 50*l.* damages for the temporary detention of the plaintiff's property, which had been returned to him before the commencement of the action, and the further sum of 850*l.* in addition to the sum of 25*l.* which the Trustees had been advised to pay into court as amply sufficient to cover the value of the articles to which the plaintiff could show even a colour of title. Notwithstanding the astonishment of the Trustees at this most unexpected result, they yielded to the advice offered by their counsel and by the court, and offered by way of compromise to give up the medals and other property claimed, and to pay the further sum of 175*l.* in addition to the 25*l.* paid into court, but this offer was rejected by the plaintiff, whereupon a *rule nisi* for a new trial was granted by the court."

THE daughter of Laplace has offered an excellent picture of her father to be copied. The family of Arago have likewise offered a picture of the illustrious astronomer. A large and excellent picture of Leverrier was in the hands of M. Bischofsheim, who wrote a letter to Admiral Mouchez, wishing him to take possession of it, at his earliest convenience, on behalf of the Observatory.

ON October 4-6 the annual meeting of ornithologists will take place at Berlin. The following papers will be read:—On the birds of the Danube forty years ago and at the present time, by E. von Homeyer (Stolp), president of the society; On the recent researches in the osteology and myology of birds with regard to classification, by Prof. Blasius (Brunswick); On an ornithological excursion to Hungary and Croatia, by Dr. Brehm (Berlin); On the latest collection of birds from Eastern Africa, by Prof. Cabanis (Berlin); On the birds of the Caucasus, by Dr. Radde (Tiflis); On the latest acquisitions of the Zoological Museum of Berlin, with special reference to the nests and eggs of African birds, by Dr. Reichenow (Berlin); On the importance of splanchnology with regard to systematics, by Herr Gadow (Algiers); On the progress of ornithology since 1875, by Herr Schalow (Berlin).

A LARGE and very brilliant meteor was observed at numerous places in Central Germany on September 6: Near Hanau it appeared in the south-east about 9.10 P.M., and looked like a large comet, with a solid nucleus and a long train of light stretching across the sky to the north-west. It appeared suddenly like a flash of lightning, and, when the nucleus had disappeared, the line of light yet remained, and little stars could be noticed in it by the naked eye. The total duration of the phenomenon was about thirty seconds.

ON September 15, at 6 to 7 P.M., a large meteor was observed at Montpellier. On the same day and at about the same time, one was witnessed at Tenez, and Constantine in Algeria, and a number of places at great distances from each other. It is not yet known whether it was the same body or if the earth met in its course a meteor swarm. The bolides were notable for their brilliancy and their duration. It is reported that at Constantine the phenomena were accompanied by noise.

A SHORT but violent shock of earthquake was felt at Buir, near Düren (Rhenish Prussia), on September 2, at 9.15 P.M. Indeed it is stated that since the great earthquake of August 26 shocks have been felt in that district almost daily. Another shock is reported from Remagen, on the Rhine, on September 3, at 1 A.M., and a third one from Wiesbaden and neighbourhood on September 14, at 11.35 P.M. The latter was particularly violent.

ACCORDING to the last official calculation the total receipts of the Exhibition from entrance-money will reach 13,000,000 francs up to the end of October. There are other sources of revenue and a subvention from the City of Paris. It is supposed that the deficit will not exceed 400,000*l.*, which will be more than covered from various sources.

QUITE recently a most remarkable new cave has been discovered in the United States near Glasgow Junction, Kentucky. It has been investigated to a distance of no less than twenty-three miles in one direction and sixteen in another. Most of its passages are very broad, and it is stated that a carriage with a pair of horses has room to drive some eleven miles into the interior. It contains several very deep rivers, one of which has been traced to a distance of fourteen miles; further progress was then arrested, the cave narrowing too much to allow a boat to pass. The cave is described to be "most wonderful," by an American contemporary, and is said to surpass in grandeur all

other caves hitherto known, the Mammoth Cave not excepted. Some human remains, resembling Egyptian mummies, were also found in the cave. They were contained in stone sarcophagi of rough structure. The floor of the cave is extremely uneven, full of fissures and irregularities, so that it seems as if violent volcanic phenomena had taken place here. The new cave has been baptised with the more or less appropriate name Grand Crystal Cave. Our readers are doubtless aware that the Mammoth Cave is also situated in the vicinity of Glasgow Junction, Kentucky.

AMONG the resolutions passed by the International Congress on Weights, Measures, and Coins, at Paris, was the following:—The Congress learns with pleasure the progress of the metric system; it deplores that England, Russia, and the United States have not yet entered into the same path; and it is of opinion that the Governments of those countries should be solicited to give effect as early as possible to an act of progress so eminently useful to science, commerce, and international relations." The British and American members had a separate meeting, and resolved to petition their respective Governments to appoint a mixed commission to consider the adoption of the metric system by both countries, and to make all necessary recommendations for the proper legislation to secure the desired end.

THE conchological collection formed by the late Dr. Marie, of New Caledonia, has been purchased by Mr. Bryce-Wright.

AT the Royal Foundry of Munich a colossal monument cast in bronze was exhibited from September 8 to 11. It is intended for St. Louis, U.S., and represents Alexander von Humboldt; the design is by Herr von Müller, jun. The figure is some 3½ metres in height, and represents Humboldt in the freshness of manhood, leaning against a stump of a tree, upon which he has deposited his mantle; in the right hand he holds a map. The statue will be placed upon a stone pedestal, which is in course of construction at St. Louis, and which will be adorned by three relief medallions by the same artist, the one on the front showing the features of the founder of the monument, Mr. Henry Shaw, of St. Louis.

THE following are the more important addresses delivered and papers read at the sectional meetings of the German Naturalists' Association at Cassel:—Mathematical and Astronomical Section: On some new solutions of the problem of the division of the ball, by Prof. E. Hess (Marburg); On the old calculating machine of Leibnitz, by Prof. Listing (Göttingen); On the solar parallax, by the same. Prof. Listing gives the value $\pi = 8'' \cdot 8786$ as the most correct one at present.—Physical and Meteorological Section: On some new magnetic phenomena, by Dr. Fromme (Göttingen); On the influence of interior friction upon resonance, by Dr. Auerbach (Breslau); On a new method of employing the induction of the earth for the determination of the magnetic inclination, by Dr. Schering (Göttingen); On a new apparatus for the distillation of mercury, by Dr. Weber (Kiel); On a case of pleochroism, by Prof. Staedel (Tübingen); On a new method and apparatus to determine low tensions of vapours, by Dr. Moser (Berlin); On some applications of total reflexion, by Prof. Kohlrausch (Würzburg); On the theory of the exchange of air through porous walls, by Prof. Recknagel (Kaiserslautern); Remarks on galvanometry, by Prof. Töppler (Dresden); On the point of gravitation in curves, planes, and solid bodies, by Dr. Feussner (Marburg); Record of observations of solar spots and protuberances, by Prof. Spörer (Potsdam); On the behaviour of different heat colours in the reflection of polarised rays from metals, by Prof. Knoblauch (Halle); On the mathematical theory of friction electricity, by Dr. Schering (Göttingen); On an improvement in the hair hygrome-

ter, by Dr. Nippoldt (Frankfort-on-the-Main). Chemical Section: On the chemical constitution of the turnip molasses, by Prof. Gunning (Amsterdam); On some new platina compounds, viz., platinofulminates, by Prof. von Meyer (Leipzig); On pyromeconic acid, by the same; On a new apparatus for the combustion of organic substances containing halogens, by Dr. Kopfer (Bonn); On the conversion of starch into sugar, by Dr. Salomon (Brunswick); On a physically isomeric modification of dinitrochlorobenzol, by Prof. Daubenheimer (Giessen); On the conditions of life of the lower organisms, by Prof. Gunning (Amsterdam); On a new method in the preparation of bromine, by Dr. Frank (Stassfurt); On some new phenomena concerning gases, by Prof. Mitscherlich. Geological and Palæontological Section: On the heat of the earth, by Herr E. Dunker (Halle); On some animal footmarks in the coloured sandstone of Carls-hafen, by Dr. Hornstein; On the geological condition of the Büdingen forest, by Dr. Bücking; On an explanation of earthquakes, by Herr von Dückler; On the tridymite of Friedrichroda (Thuringia), by Dr. Luedecke; On basalt and its decay, by Dr. Franke; On the geological condition of the Kyffhäuser mountain, by Dr. Moesta. Geographical Section: On the botanical aspect of the Caucasus, by Dr. Raddé; On an exploring expedition to San José de Cucuta (South America), by Dr. K. Müller (Halle); On mountain and valley winds and their effect upon the vegetation of volcanic mountains, by Prof. Rein (Marburg); Ethnological researches in the Island of Cyprus, by Herr Schmölder (Frankfort); On the progress of the commercial relations between Europe and Western Siberia, by Dr. M. Lindemann (Bremen). Numerous papers and treatises were read at the zoological, botanical, anatomical, and physiological section-meetings, but by far the greater part were of minor interest, most of them having special reference to medicine only. The medical sections were as numerous as last year at Munich, and the attendance was, if anything, greater than on any previous occasion.

THE Aeronautical Society has issued its twelfth annual report. To it, in accordance with the expressed intention to reprint any matter of interest which might be otherwise unattainable, is annexed a reprint of a pamphlet printed in the year 1810 by Thos. Walker, of Hull, its title being "A Treatise on the Art of Flying by Mechanical Means." Mr. Walker was a portrait painter. An American would say that the treatise was a little "mixed."

THE physicists of the French Central Bureau of Meteorology are engaged in establishing a nomenclature to diminish the number of letters used in signalling.

THE American Academy of Arts and Sciences is probably one of the most active and efficient scientific societies anywhere; its *Proceedings* will bear comparison with those of any society in the old country. The part before us, including the period from November, 1877, to May, 1878, contains a number of papers of great value, the titles of which we shall give meantime, in the hope of being able to notice some of them in detail shortly. The Moon's Zodiacal Light; Undulations Observed in the Tail of Coggia's Comet, 1874; Sudden Extinction of the Light of a Solar Protuberance; On Saturn's Rings, by L. Trouvelot; Supplementary Note on the Theory of the Horizontal Photoheliograph, by Prof. William Harkness, U.S. Navy; Researches on the Substituted Benzyl Compounds, by C. Loring Jackson; Remarks on the Brain, illustrated by the Description of the Brain of a Distinguished Man, by Thomas Dwight, M.D.; Theory of Absorption-Bands in the Spectrum, and its Bearing in Photography and Chemistry, by Dr. Robert Amory; Surfaces of the Second Order, as treated by Quaternions, by Abbott Lawrence Lowell; On the Synonymy of some Species of Uredineæ, by W. G. Farlow; Metasomatic Deve-

lopment of the Copper-bearing Rocks of Lake Superior, by Raphael Pumpelly; Investigations in Quaternions, by Washington Irving Stringham; On a New Method for the Separation and Subsequent Treatment of Precipitates in Chemical Analysis, by F. A. Gooch; On Peirce's Criterion, by Benjamin Peirce; Note on the Measurement of Short Lengths, by Leonard Waldo; Contributions to the Botany of North America, by Asa Gray; Spherical Conics, by Gerrit Smith Sykes; On the Influence of Internal Friction upon the Correction of the Length of the Second's Pendulum for the Flexibility of the Support, by C. S. Peirce; Colour Perception, by G. Stanley Hall; On the Intensity of Terrestrial Magnetism at Cambridge, by Henry Goldmark. Among the foreign honorary members we find the names of J. C. Adams, Airy, Cayley, Sylvester, Clerk-Maxwell, Balfour Stewart, Stokes, Sir Wm. Thomson, Darwin, Joule, W. H. Miller, A. C. Ramsay, Sabini, Bentham, Hooker, Owen, Max Müller, Rawlinson, Gladstone, Tennyson.

THE receipts of the Giffard Captive Balloon on the first sixty days have been more than 500,000 francs. The sum spent on the construction of the balloon has been realised. It is supposed that the receipts for the month of October will be sufficient to cover the working expenses, so that M. Giffard will be rewarded for his enterprise by the possession of the balloon, machinery, and gas-producing apparatus.

A MILLION tickets have been sold at one franc each for the Paris Exhibition Lottery. Two-thirds of the sum are to be spent in purchasing prizes, the other third being destined to assist the Government in paying the travelling expenses of the working men visiting the Exhibition.

THE additions to the Zoological Society's Gardens during the past week include two Ostriches (*Struthio camelus*) from Africa, presented by the Hon. H. C. Vivian, H.B.M. Consul-General; two Secretary Vultures (*Serpentarius reptilivorus*) from South Africa, presented by C. Rivers Wilson, C.B.; an Oriental Eagle Owl (*Bubo orientalis*) from Karenee, Siam, presented by Mr. Charles Fowler; two Prairie Marmots (*Cynomys ludovicianus*) from North America, two Smaller Rattlesnakes (*Crotalus miliaris*) from Canada, presented by Mr. Wilfred G. Marshall; two Egyptian Gazelles (*Gazella dorcas*) from Egypt, presented by Mr. Thomas Moss; three Reddish Finches (*Spermophila nigro-aurantia*), one Bluish Finch (*Spermophila carulescens*), one Half-white Finch (*Spermophila hypoleuca*), one Tropical Seed Finch (*Oryzoborus torridus*) from South America, presented by Mr. R. C. Batterbee; three Rufous Tinamous (*Rhynchotus rufescens*) from Brazil, presented by Mr. J. A. Iliffe; two Lesser Black-backed Gulls (*Larus fuscus*), British Isles, presented by Mr. A. H. Cocks, F.Z.S.

THE FIGURE AND SIZE OF THE EARTH¹

II.

IN addition to the measurement by Picard above-mentioned, two other arcs were measured in a north and south direction; La Hire measured northward towards Dunkirk, and Cassini southwards towards Perpignan. The result, published by Cassini in the year 1718, was as follows:—The southern arc gave 57098 toises (Picard's was 57060), and the northern 56960. This result was quite opposed to Newton's theory; it indeed favoured an elongated figure for the earth. There now began among the learned of the time a controversy which was carried on with much bitterness, between the supporters of Newton and Huyghens on the one hand, and of Cassini on the other. Cassini published the results of his measurements in his work, "De la Grandeur et de la Figure de la Terre" (Paris, 1722), and in consequence of the high reputation which he, as Director of the Observatory and member of the Academy, possessed over all France, nearly all the

French *savants* took his side. But the arguments adduced by him were not such as could convince the great number of Newton's followers in all other nations. The French results were all the more objected to, that the measured arcs were much too small to allow one to base thereon a conclusion as to the form of the earth. In order to bring to an end the controversy carried on with so much violence on both sides, the French Government sent out in the year 1735 an expedition, consisting of the astronomers Bouguer, de la Condamine, and Godin, to Peru to measure the length of an equatorial degree. A second expedition, consisting of the academicians Maupertuis, Clairaut, and Lemonnier, was sent to Lapland; and while the former found the length of a degree at the equator to be 56753 toises, the latter, in connection with Celsius, found the result in latitude 66° 20' to be 57437 toises. These results, obtained from the most careful observations and the most accurate calculations, gave the palm to the Newtonian theory, and the amount of flattening as ascertained so nearly agreed with Newton's calculation as to give the greatest confidence in his works.

It should, however, be mentioned that the Lapland measurement was much behind the Peruvian in correctness. Indeed it was soon seen that it was much more inaccurate than Picard's, and therefore the flattening of the earth was based only on Picard's and the Peruvian measurements. But the admirable execution of the Peruvian measurements was of importance also in another respect; in it, two base-measurements had been made, the southern base being considered a base of verification. This importance, which appeared at a later period, consisted in the fact that the unit of measure used in laying down the base-line, the "Toise of Peru," after it had with the greatest care been brought to Paris uninjured, was instated as the French normal measure, and this standard, at a temperature of 13° R., was appointed as the legal measure of length for France.

At a later period Freiherr von Zach reduced the length² of an equatorial degree to the sea-level and found it to be 56732 toises. He made use for this purpose of a second measurement at the equator, carried out by the Spaniards (assisted by Godin) between Cuenza and Mira, which embraced a length of 3° 26' 52" and gave 56768 toises as the length of a degree. Since the careful measurement of a degree in Peru—which put a final end to the opposition to the Newtonian theory of the figure of the earth as opposed to the view of Cassini, and proved to all the world as an undoubted fact, that the inhabitants of the earth did not live upon a perfectly spherical planet, but on one flattened at the poles; since then has also grown the universal desire for accurate knowledge of the dimensions of the earth, as from the amount of its deviation from the spherical form, we expect to form important conclusions as to the origin and development of our planet. Meantime the great progress made in methods of measurement and in instruments, combined with the beautiful results of the constantly-developing mathematical sciences, now promised the best results for new undertakings in reference to measurements of the earth.

Although the degree measurements carried out up to the middle of last century left no further doubt as to the spheroidal form of the earth, yet, as already said, the Peruvian measurement was the only one that had been carried out with the greatest possible accuracy. But on combining this arc with the French, Lapland, and other known measurements, only differing from it in point of accuracy, results differing much from each other were obtained. If we represent the polar and equatorial semi-diameters by the letters a and b , the quotient $\frac{a-b}{a}$ represents the amount

of flattening. We thus obtain, by combining the Peruvian and the Lapland measurements, the value $\frac{1}{215}$, the Peruvian and French $\frac{1}{364}$, and lastly, the French and Lapland $\frac{1}{115}$. To understand in what way, by means of the data for the length of a degree, and the combining of the data for two or more different parts of the earth's surface, it would lead us to the amount of the flattening, requires considerable knowledge of the higher mathematical methods, and we must not, therefore, enter here on this part of the subject.

The great differences between the three values referred to, showed how untrustworthy were the measurements hitherto obtained, and this led to endeavours in many quarters to come nearer to the truth by better measurements. Lacaille availed himself in 1750 of his stay at the Cape of Good Hope to carry out the measurement of a degree, and found for S. lat. 33° 18' 30",

¹ This probably refers to the reduction by the Baron de Zach of the observations made in the Peruvian operations.—*Mon. Corresp.*, xxvi., p. 52.

² Continued from p. 553.